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Integrating science, policy and farmers to reduce soil loss and sediment delivery in Flanders, Belgium

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Abstract

This paper describes the evolution of soil erosion perception with policy makers and farmers in Flanders, and how these changes have resulted in the emergence of a soil conservation policy. Until the mid 1990s, soil erosion and its related problems received little attention in the environmental debate. This has changed through increased interest in environmental issues in general, as well as an increasing number of scientific reports on soil erosion and sediment delivery. New legislation that made the sediment problem a big financial issue in 1995, however, was the main reason for the recognition of soil erosion as an environmental problem with the policy makers. Despite the lack of monitoring soil erosion, a soil conservation policy emerged recently, which is clearly represented in the 2001 "soil erosion decree" by the Flemish government. This policy provides important opportunities for soil conservation as it incorporates both scientists and farmers. The involvement of farmers in demonstration projects is crucial with this respect as they have to be convinced about the usefulness and applicability of soil conservation measures. Farmers also participate in the development of a management plan. However, the success of the new policy could be undermined by its rapid development. There is still a lack of data underpinning the status of the erosion problem, and, the goals of the policy are not clearly defined. Furthermore, the administrative organisation is currently not favourable for an optimal co-operation with the farmers.

Keywords: Belgium; Erosion control policy; Catchment management; Science and policy; Administrative decision making; Participatory management

1. Introduction

Soil erosion by water on cultivated land is causing a number of environmental problems throughout the world. This is certainly the case for the hilly regions in the Loess Belt of central Belgium. After intense rain events, mainly in late spring–early summer, many villages in central Belgium are confronted with muddy floods originating from intensively cultivated fields (Verstraeten and Poesen, 1999). Similar problems have been reported from other regions in the north-western European Loess Belt (Boardman et al., 1994), and in particular in the South Downs, UK (Boardman, 1995), northern France (Papy and Douyer, 1991) and the south-eastern corner of The Netherlands (Schouten et al., 1985). These muddy floods not only cause serious inconvenience but also important financial and psychological damage to the local population. Soil erosion by water is also responsible for high suspended sediment loads in rivers. This results at some locations in silting of rivers leading to increased flood risk as discharge capacity of the river decreases. For the larger rivers in the northern part of Belgium, sediment deposition is hindering navigation as well, especially in the vicinity of locks. Furthermore, many retention ponds that were constructed on rivers to reduce the frequency and magnitude of flooding events, are experiencing high sediment deposition rates. Also, these ponds loose their functional retention capacity in only a few years (Verstraeten and Poesen, 1999). As a result, rivers as well as retention ponds need to be dredged quite frequently, which is a costly operation. Sediments are also polluted with nutrients from fertilizers as well as with other contaminants (heavy metals, PCBs) originating from sewage water that is mixed with runoff water. For a densely populated and well-developed country, these off-site damages relating to soil erosion by water are, given the short-term economic consequences, far more important than on-site damage. The latter includes loss of fertile soil, fertilizers and crops, but also a more difficult access to fields due to ephemeral gullies.

This wide range of environmental problems demands a response that reduces soil loss from fields as well as sediment delivery to villages, rivers and ponds. In this respect, a number of questions can be raised: what should the response be? What measures need to be taken to achieve a reduction

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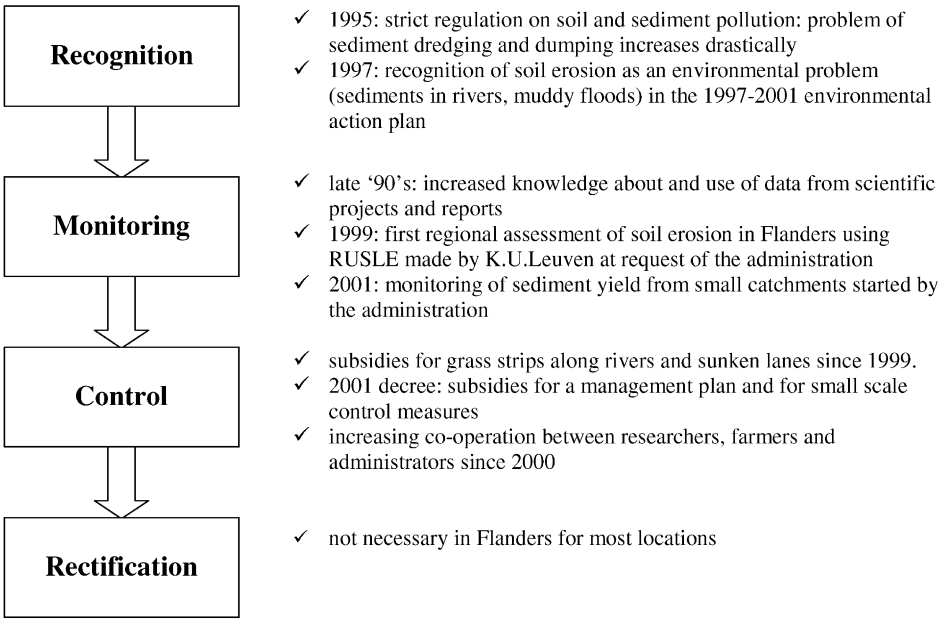

Fig. 1. Scheme illustrating the different stages necessary for soil protection (after Blum (1990); cited in Higgitt (1991)) and the corresponding evolution in Flanders.

in soil loss and sediment delivery? Where need these measures be taken? Who will be responsible for such a response and who should be involved? In most cases, it will be the government that needs to take action. But to what extent can scientists aid in such a response? And, finally, what is the role of the farmers? In this paper, we will address some of these questions. In Belgium, the regions are responsible for environmental issues, so we will limit this discussion to the region of Flanders. In order to improve soil protection, Blum (1990, cited in Higgitt (1991)) argued that one has to go through four stages: recognition of the problem, monitoring, control and rectification (Fig. 1). For Flanders, we can skip the last stage, except for those locations where large ephemeral gullies evolved to permanent gullies or in the case of bank gullies, some rectification may be necessary. We will discuss how the government in Flanders has moved through this scheme over the last decades.

2. Policy perception of the soil erosion problem and response

2.1. Problem perception and recognition

In the past, only off-site damage related to soil erosion on cultivated fields was acknowledged by policy makers, and even then, the link with soil erosion was hardly made. For instance, it was established for decades that high levels of suspended sediment in the river Scheldt were mostly originating from soil loss in upland areas (e.g. Dhondt and Jacques, 1982), whereas De Ploey (1986) pointed to non-tolerable soil losses by water erosion and the related off-site damages. However, the administration responsible for the lowland rivers in Flanders who has to deal with sediment deposition problems in these rivers, never sought the solution to their problems in erosion control practices upstream. A similar attitude could be observed towards flooding. Over the last two to three decades, more than 100 flood retention ponds have been constructed in Flanders in order to prevent flooding of villages and public infrastructure after intense rain events. Before 1997, only 15% of these ponds were built with the aim to control muddy floods originating from arable land (Verstraeten and Poesen, 1999). All the other ponds are located on rivers and do not prevent flooding from direct runoff from cultivated land. Nevertheless, many of these ponds were also constructed to prevent floods with a highly muddy character. It was, however, not readily recognised that the mud in the water came from arable land several kilometres upstream. These ponds also trapped sediment, which gave rise to new problems. Rapid siltation of these ponds, however, contributed to an increased awareness of the sediment problem. This has certainly become the case since 1995 when a new set of regulations in Flanders made it very expensive to dredge and dump sediment from rivers and ponds (VLAREBO and VLAREA; http://www.ovam.be). The first of these new regulations (VLAREBO or the soil remediation decree) was issued mainly for contaminated soils, but it also had implications for sediments. Indeed, when pond or riverbed sediments were dredged and put on the soil next to the river or pond, the sediment became a soil. If the sediment is polluted, also the new soil on the riverbank will be polluted. New contamination is not possible with

VLAREBO thus, the contaminated sediment needs to be removed. However, the other new regulation (VLAREA or the waste prevention and management decree) stipulates how waste material (in this case dredged sediment) can be used as a resource in, e.g. landfills or road construction, in function of the contamination level. In many cases the pollution level of the sediment is that high that it can not be used as a new resource, but that is has to be cleaned or dumped on specific dumping grounds. A quite simple operation of dredging rivers and small ponds, and dumping the sediment on the banks of the river or pond now became a huge effort (both financial and laborious as the sediment first needed to be analysed). Whereas the disposal of riverbed or pond sediment deposits cost around € 10 m^{-3} before 1995, this has become € 50 m^{-3} for medium polluted sediments and up to € 125 m^{-3} for more seriously polluted sediments. Administrators of rivers and ponds were now faced with the fact that they did not have the financial resources and the place to dump the polluted sediment. As a result, the need for a reduction in sediment delivery to the rivers and ponds became urgent. It also resulted in a growing awareness with the policy makers that measures need to be taken near the source of the problem, being soil loss from arable land. Within the Flemish environmental action plan 1997–2001, soil erosion was for the first time recognized as an environmental problem, mainly as a source of sediment in rivers as well as a cause of muddy floods. However, at this point, no action was taken. This recognition was a very important step: although many people working in the administration already acknowledged the importance of soil erosion through their own field observations, it was the first time that this was the case for the higher levels in the administration, and even more important, for the policy makers.

It would take, however, a few more years before the on-site consequences of soil erosion were also considered as a problem. With the upcoming environmental action plan 2003–2007, soil erosion will be recognized as being a threat to the longer-term sustainability of our soils. The soil is regarded as a multifunctional and non-renewable resource. Therefore, the new environmental action plan will not only recognize the problem, but it will also include soil protection through soil erosion control.

2.2. Policy response and control

Given the increased awareness that soil erosion is responsible for a variety of environmental problems, and that it causes an irreversible degradation of the soil, the Flemish government has recently taken a major step forward by issuing a new regulation that has the objective explicitly to decrease on-site soil loss as well as the downstream impacts of sediments. In December 2001, the Flemish Government issued a decree concerning “the subsidy of small-scale erosion control measures to be taken by local authorities”. This decree regulates subsidies to the municipalities on two levels. First, each municipality in the hilly regions of Flanders is requested to make an erosion control management plan indicating where and which measures will be taken. The municipality receives an amount of € 12.5 ha^{-1} to make such a plan. Secondly, for control measures indicated on the plan, and that are approved by the Flemish administration, there is a 75% subsidy for the implementation of the measures in the field. The measures that can be subsidized need to be chosen from a “Code of good practices—erosion control” which is currently being prepared by the Flemish administration. It will include mostly small-scale technical control measures like the construction of small dams and pools or grass buffer strips. Soil conservation measures on fields, like for instance conservation tillage, cover crops or grassed waterways, are at present not foreseen in this decree. However, because of other environmental reasons than soil protection, farmers can be subsidized annually for sowing cover crops in autumn (€ 50 ha^{-1}) and for sowing grass strips with a width of 5–10 m along rivers and sunken lanes (€ 0.12 m^{-2}). These practices are now also promoted to farmers in the framework of the erosion control policy. It is expected that more agricultural practices that reduce soil erosion will be encouraged through subsidies, as long as these measures fit into the “Plan for the development of rural areas”, which first needs to be approved by the EU-commission. This is not expected before the end of 2003.

These recent developments in soil erosion and sediment delivery control in Flanders, clearly indicate that the Flemish government has moved to the third and final stage of soil protection as pointed out by Blum (1990, cited in Higgitt (1991); Fig. 1).

3. The role of science in the recognition and control of soil erosion

Scientists played an important role in the development of problem perception and control as described above. It was mainly the results from scientific studies that revealed the magnitude and severity of soil loss and sediment delivery to people working in the administration, and later also to policy makers. Further interaction between the administration and soil erosion scientists increased the perception with the former that soil erosion is a source of a variety of environmental problems, not just a natural process occurring on fields, and thus a problem for the farmer alone. One of the most important role that the soil erosion research community has played is to contribute to monitoring the problem. Whereas the administration recently recognized the problem and even started with some control measures, they almost completely neglected the monitoring part (Fig. 1). This is quite problematic as any good functioning control policy should be oriented towards areas that are at higher risk, instead of spreading financial incentives to the whole of Flanders. This is certainly the case for soil erosion, which has important spatial variations that should not be overlooked (Boardman, 1998). To aid the administration in defin-

ing those areas where soil erosion and sediment delivery is important, and thus where their control policy should be directed, both measured and modelled research data were delivered. Van Rompaey et al. (1999) made, for instance, a soil erosion map for Flanders using the Revised Universal Soil Loss Equation-methodology (RUSLE, Renard et al., 1997), upon request by the Flemish administration. For sediment yield, only limited data for smaller catchments in Flanders are available (Verstraeten and Poesen, 2001). The only attempt that was made by the administration to increase their knowledge of the actual sediment delivery to the rivers in Flanders, was the setting up of a suspended sediment sampling programme on small rivers. This programme started in 2001 and is still expanding. Scientists also contributed general information on how to set-up a sediment monitoring programme to the administration.

Although the knowledge and information that scientists have shared with policy makers has certainly contributed in the perception of the soil erosion problem and the setting up of a control policy, their importance should not be overestimated. The decision of the Flemish government that soil erosion should be reduced (the 2001 decree, see above) was only possible with the current coalition between liberals, socialists and the green party. The minister of environment in this legislation is for the first time also the minister of agriculture, and, she is a member of the green party. Before the present legislation, the catholic party ruled the ministry of agriculture for almost half a century and therefore, the influence of the (catholic) farmers' organisation on the minister of agriculture was quite important. The change in government coalition in 1999 has therefore created new possibilities for environmental protection, including soil protection. It can be seriously questioned whether this would have been possible if the former government had been re-elected. In addition, the role of a few dynamic people in the lower levels of the administration was very important as they confronted the new policy makers with scientific reports, pictures from muddy floods and intense soil degradation, numerous newspaper reports on muddy floods, as well as with invoices from maintenance operations on roads and rivers after intense rain events. Furthermore, the role of scientists could only be influential in the framework of growing environmental interest by the public and the policy makers since the 1992 Earth Summit in Rio de Janeiro, which is widely recognized as a turning point in the conservation of the earth (Kress et al., 2002; Ten Kate, 2002).

In the framework of the erosion control programme, scientists also provided more information on the various soil conservation measures and sediment delivery control techniques that are available, and the locations in the landscape where these measures need to be taken to be most effective. A soil erosion and sediment delivery model that was developed at the Laboratory for Experimental Geomorphology (K.U. Leuven) was used to model the impact of various scenarios of an integrated catchment response for three catchments in one single municipality (Verstraeten et al., 2002). This project was funded and viewed as a pilot project by the administration that needs to co-ordinate erosion control management plans that are subsidized according to the 2001 decree. Fig. 2 shows how within the three studied catchments, more than 60 sub-catchments ranging from 20 to 260 ha were subdivided in four "risk categories" for soil loss as well as for sediment delivery. Such maps can be used in the development of the final management plan in order to restrict control measures to only those areas at high risk. It is clear that for controlling soil loss, other priority areas need to be selected than for controlling sediment delivery. This is not a straightforward conclusion for policy makers and a modelling approach like this is needed to make it clear. Not only sub-catchments, but even individual fields can be highlighted with such a modelling effort. Once the main problem areas are defined, one can simulate a variety of control measures. Table 1 illustrates the expected effect of some of the possible measures that can be taken in three small catchments. This includes the construction of small ponds to prevent runoff and sediment entering villages, the establishment

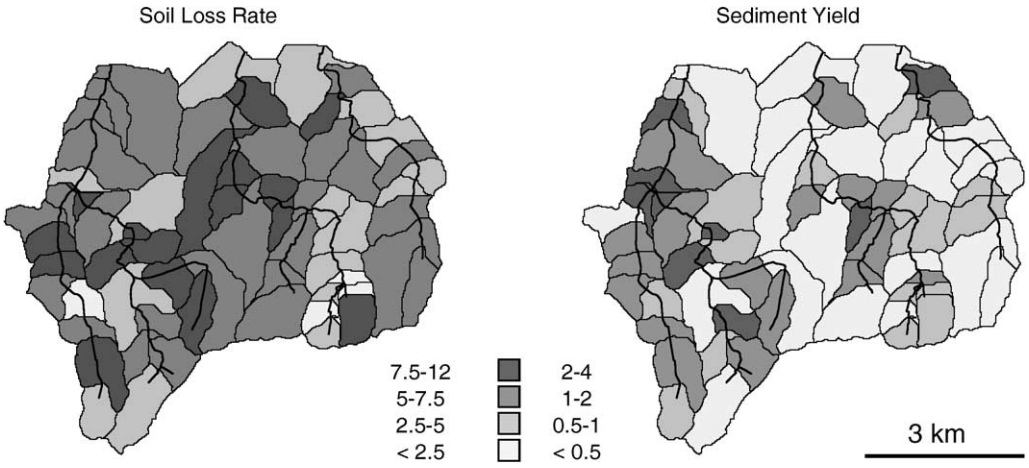

Fig. 2. Modelled mean annual soil loss and sediment delivery for 65 sub-catchments in one municipality in Flanders (51 km^2), divided into four intensities ($t\,ha^{-1}$ per year) or risk categories (after Verstraeten et al., 2002).

Table 1
Simulated impact of various management scenarios on soil loss and sediment yield for three catchments in Flanders (51 km^2; after Verstraeten et al., 2002)

S. no.	Scenario	Soil loss reduction (%)	Sediment yield reduction (%)
1	6 Ponds	–	12
2	17 Ponds	–	14
3	Filling ditches	–	12
4	GS along rivers	2	19
5	GS along field borders	3	7
6	SC on all fields	35	33
7	SC on fields high soil loss	18	13
8	Set-aside 5%[a]	5	2
9	Set-aside 10%[a]	13	9
10	Set-aside 15%[a]	19	12
11	Set-aside 20%[a]	25	18
12	Set-aside 5%[b]	13	17
13	Set-aside 10%[b]	22	25
14	Set-aside 15%[b]	30	31
15	Set-aside 20%[b]	38	35

GS: grass buffer strips; SC: soil conservation measures.
[a] Set-aside parcels selected using a probability model (Van Rompaey et al., 2001).
[b] Parcels with the highest soil loss selected for set-aside.

of grass buffer strips along rivers or at the downstream field border, the removal of drainage ditches which are important conveyors of sediment, the implementation of agricultural practices for within-field soil conservation, as well as different percentages of fields that are set-aside (i.e. conversion of arable land to pasture or forest) using two field selection procedures. In practice, a combination of different measures will be implemented at various places. The ultimate set of measures that will be integrated in the erosion control management plan, however, will be the result of intense discussions with farmers (see below), local and regional administrators, and those who will create the plan, which will not be the scientists. Indeed, the role of scientists will be limited to providing a general overview of the problem and what actions can be taken, all which can be aided through modelling, but the contacts with local stakeholders and technical development of the plan as well as the execution can best be done through a consultancy firm.

4. The role of farmers in soil erosion control management

In the past, farmers were little concerned about soil erosion on their fields. It was not perceived as being an important problem, and this feeling was strongly supported by the powerful farmers' organisations. Regional press conferences held by the late Jan De Ploey in the mid 1980s on the severity of the soil erosion problem and the possibility of reduced tillage to control soil erosion (De Ploey, 1988), for instance, were laughed off by the farmers' organisation. Although being perceived as an excellent soil erosion researcher throughout Europe, De Ploey's comments on the situation in Flanders were attacked by most farmers: it is the farmers that know how to plough their fields and no one else should tell them how to do this. Farmers were also not concerned about downstream consequences of soil erosion, like muddy floods in the villages. Even in the mid 1990s, the authors witnessed at several meetings between local farmers and villagers the view that according to the farmers, muddy floods should be blamed on the people who where "so stupid as to build in those places", whereas "the water has always run down the slope". The resistance of farmers to doing something about excessive soil erosion, even in the 1990s when it became clear that soil erosion was responsible for the muddy character of floods, can be explained partly by the enormous pressure on them regarding other environmental issues, especially the manure problem. For decades, farmers were their own boss, but since the early 1990s, there were restrictions put on the use of manure as a fertilizer, mainly to combat pollution of ground water and eutrophication of surface waters. The soil erosion issue was perceived as another "attack" on their individual rights.

However, more and more environmental and public health issues were related to farming operations (e.g. mad cow disease or dioxins in chickens) and it became very difficult for the farmers to deny their share. Again, the change in government (which was to a large part due to the chicken dioxin crisis that came out 1 month before the 1999 elections) played a very important role here as their grip on agricultural policy was reduced substantially. Probably the most important change in recent years is the successful interaction between farmers, scientists and even policy makers. This is, for instance, illustrated in a number of LIFE demonstration projects that started in the late 1990s bringing together local municipalities, regional administrations, researchers and consultancy firms. Furthermore, in January 2001 an 'erosion control' research and demonstration programme funded by the Flemish government started. Within this project, the two universities (K.U. Leuven and University of Ghent) in Flanders where soil erosion research is conducted, participate together with the administration and in close contact with the farmers. The aim of the project is to produce a guideline book of erosion control measures. This manual should become an important document to be used by government officials when providing better information to farmers on anti-erosion agricultural practices. Within the framework of this project, several soil conservation measures are demonstrated to the farmers as well. On several fields throughout Flanders, grass buffer strips are installed by the University of Ghent to illustrate their potential for trapping eroded sediment. Furthermore, K.U. Leuven-researchers made several paired demonstration plots on fields to show the farmers the impact of various conservation tillage practices on soil loss compared to conventional tillage practices. Every year, farmers are invited to visit the demonstration plots and the results are presented together. They also get information on more practical issues like the type of tillage equipment

that is needed or the various treatments that need to be applied, as well as the economic implications for the farmer. These issues are often lacking in reports on soil conservation techniques where mostly only the impact on soil loss is described. This information is communicated by the farmer on whose field the experiments were conducted. The role of young and innovative farmers is crucial in this respect. When they started to recognize soil erosion as a problem and tried to do something about it, they also convinced other farmers to do the same. Nowadays, many farmers report to each other the results from experimental plots and many have requested to participate in the project in the next year, i.e. they would like to have an experimental or demonstration plot on their fields as well. The increased attention of the local press, who regularly reports on these demonstration plots, has probably contributed to this "enthusiasm" among farmers. It appears now that many farmers are very proud if they can co-operate in such an erosion control project, which is in sharp contrast to their behaviour a few years ago. In fact, we can state that the main objective of a farmer was used to be to achieve the highest possible yields, whereas today, farmers are more and more willing to act as a protector of the environment.

The experience with the demonstration projects did teach us that farmers must see the treatment and its impact before they are truly convinced. This was again illustrated after a moderate rain event in May 2002 (Fig. 3). On a maize field that was separated in two parts, one with conventional tillage and the other with conservation tillage, rills were only formed on the former part. The farmer who cultivated these fields was quite surprised when he did saw this and immediately reported to us saying "I will never plough my fields anymore" clearly illustrating he was convinced about the usefulness of the practice. This farmer, however, had already co-operated with the Laboratory for Experimental Geomorphology for more than 20 years in various soil erosion research projects. Many erosion surveys on his fields have been conducted illustrating that soil loss was not negligible. Nevertheless, he needed to be convinced by seeing the impact of conservation agriculture himself, not by researchers or policy makers. This is not exclusive to farmers, however. Nearly every technological innovation needs to be made in co-operation with the end users in order to become successful. Using this strategy, a new technique for controlling ephemeral gully erosion in winter wheat fields is currently being promoted to farmers, namely the double sowing of small grains in concentrated flow zones (Gyssels et al., 2002).

The developments sketched above illustrate that in order to create a successful erosion control policy, farmers have to

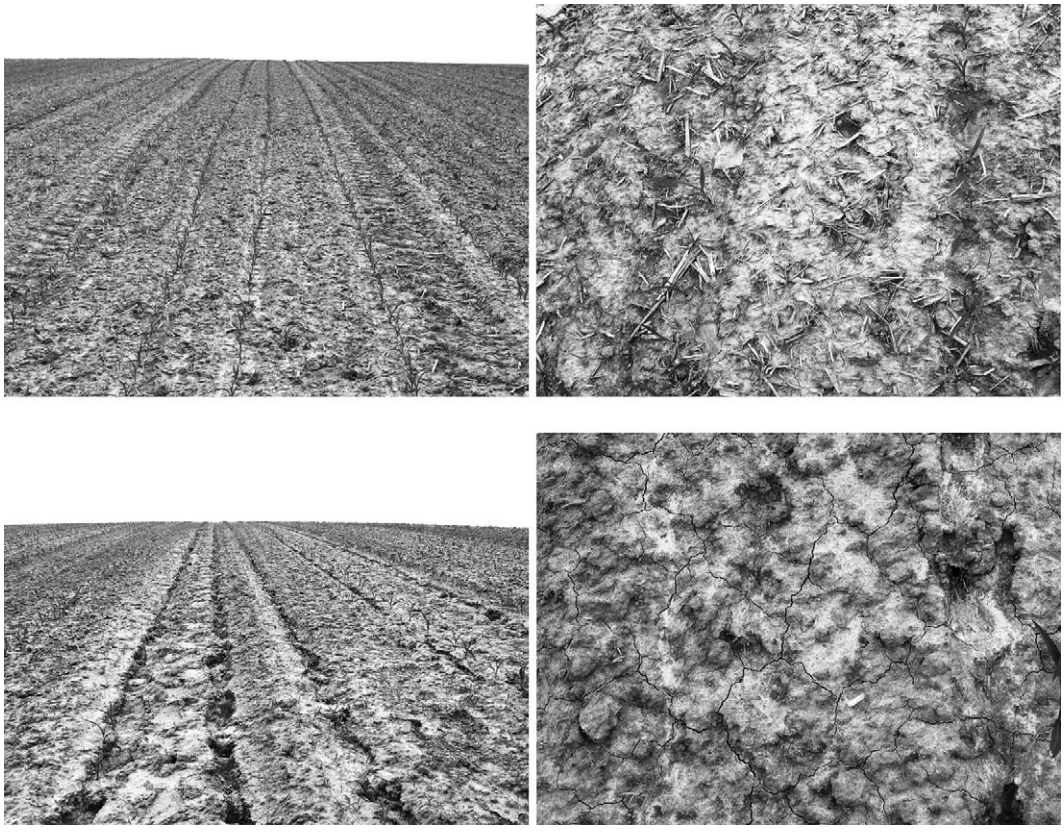

Fig. 3. Photos showing evidence of the influence of conservation tillage on soil degradation and soil loss after a moderate rain event in May 2002 in the Belgian Loess Belt. Top: the maize field with conservation tillage has no rills and the soil surface is relatively rough with a significant cover by residues from the previous crop. Bottom: the maize field with conventional tillage, has rills and the soil surface is completely sealed.

be involved in the early stages of the programme. A participatory approach to catchment management has been shown to be successful in many studies, although mostly in developing countries (e.g. Kanmegne and Degrande, 2002; Poudel et al., 2000; David, 1995; Versfeld, 1995; Pretty and Shah, 1997). Few reports are made of participatory management in the developed world (e.g. Power et al., 2000 or Martin and Lockie, 1993) as if this would not be necessary for rich and well-educated societies. Our experience in Flanders clearly suggests that even in one of the top regions in the world with respect to education and technological innovations, the interaction with the people involved remains necessary, instead of using a top–down approach.

Farmers will also play a role in the development of catchment management plan as is required by the 2001 subsidy decree. The guidelines for such a plan explicitly state that farmers should be consulted in the early stages of the making of the plan. First of all, a session with all the farmers in the area needs to be held to provide general information and a discussion of the objectives of the plan. Farmers cultivating fields in the same area then discuss a first proposal by the administration or the consultancy company that makes the catchment management plan. During this session, and also later on during individual contacts with farmers on the field, farmers discuss maps that result from, for instance, the modelling part, and further elaborate what measures they prefer on their fields and what is achievable.

5. Further needs for a successful soil erosion control policy

It is clear that in only a few years, the situation in Flanders has changed immensely from a situation where soil erosion was hardly perceived as a problem to one where a soil erosion control policy is set-up by the government. We, as soil erosion researchers, can only be happy with this development, however, we believe it has some deficiencies which could undermine the whole policy. First of all, things are going too fast in a way. No serious monitoring effort has been made to check the results of the modelling efforts like, for instance, the soil erosion map (Van Rompaey et al., 1999). Also, for Flanders it is not readily known what the impact of various soil conservation measures will be. Most of these techniques have been applied in other regions, mostly in the North America, but little is known about their application in a western European context. Especially the way these conservation techniques can be applied in a different sociological and economic context remains unclear. If the policy now encourages certain measures to be taken before their appropriateness is properly investigated, we risk that after a few years farmers loose their faith in the policy completely. We therefore suggest that more demonstration fields are needed for various control measures for at least a few years before these measures are promoted to farmers: constantly incorporating new techniques in the daily life of the farmer will not be possible. Also, several techniques that are now communicated to farmers as possible control measures are currently not being subsidized. Farmers may not be patient enough to wait for years before the EU approves subsidies for practices like conservation tillage or grassed waterways, or they may loose their belief in these practices. The implementation of certain practices is highly dependent on whether or not subsidies are involved.

In Flanders, the administration for environmental and agricultural issues is scattered over different divisions and institutions. The Land Division, for instance, is mainly interested in reducing on-site soil loss, whereas the Water Division wants to reduce the sediment input in the rivers. Much of the arable land is also under the administration of the Land Consolidation Institution (VLM; Vlaamse Landmaatschappij) and the Environmental Institute (VMM; Vlaamse Milieumaatschappij) is mainly concerned about water quality (with particular attention to nitrates, heavy metals, PCBs, chlorides, etc. but not sediment). This scatter of responsibilities, combined with the competition between them, makes it very difficult to implement an integrated environmental management in a proper way. The last few years, almost everyone involved in the administration of the environment seems to have discovered the erosion debate and is eager to set-up its own projects for erosion control. This may lead to confusion with the farmers as they have different sources of information and different opinions as well. Within this jungle of information, it is very difficult for the farmer to decide who is right and what is to be done. Thus, there is a need for a more stringent organisation of the whole soil conservation policy, which should eventually be implemented in a broader environmental policy. It would be optimal if farmers have only one single resource for information or for filling in forms, etc. for all environmental issues, ranging from soil conservation to set-aside to manure application rates and transport.

Finally, it is not clear what is the main goal that the policy on soil conservation would like to achieve, thus it is also difficult to select the best management. An optimal scenario of management to reduce soil loss and sediment delivery can be chosen by selecting either the most effective set of measures (i.e. those that most reduces soil loss and/or sediment delivery) or the one that is most efficient (i.e. where the benefits are highest compared to the costs). The problem is, however, that currently no accurate cost–benefit analysis can be made as the economic evaluation of certain environmental aspects remains unresolved. The value of the soil, for instance, is not known. In most studies, only the medium-term (50 years) loss in productivity through soil degradation is considered (e.g. Xu and Prato, 1995; Pimentel et al., 1995). However, if the soil is considered as a non-renewable resource that should sustain the productivity for the next generations (but how many?), its value will be much higher, yet unknown at present. The goal can also be a maximum tolerable soil loss or sediment delivery. However, how high is this maximum tolerable soil loss? Various thresholds for soil loss have been

put forward (Morgan, 1995) but the value strongly depends on local situations (e.g. soil thickness and fertility), and at what temporal scale one is looking. A soil loss of $10\,t\,ha^{-1}$ per year might be tolerable for certain fields to sustain productivity at the present level for another 30 year but a value of less than $1\,t\,ha^{-1}$ is not unrealistic if the time frame is 1000 year. Furthermore, a soil loss of $5\,t\,ha^{-1}$ can be tolerable for controlling on-site soil degradation but can still cause too much damage downstream. These thresholds also vary spatially with changes in soil fertility and soil thickness. One single threshold for the whole of Flanders is thus not ideal but for which spatial scale should a threshold apply? At the scale of a region, an individual field or even a few square meters? The same holds for sediment delivery. At present no criteria are set by the administration. It would be better if the current policy had clear goals as the set of measures that need to be taken to achieve these goals are dependent on this. It is not clear whether these criteria should be determined by the policy makers or by scientists. This certainly requires more study.

6. Conclusions

The overview on soil erosion perception and control policy indicated that in recent years many things have changed quite drastically. Till the mid 1990s, soil erosion was hardly recognized as being an environmental problem with both policy makers and farmers. Due to increased public interest in environmental issues, an increasing number of scientific reports on soil erosion and sediment delivery, but mostly through new legislation that made the sediment problem a serious financial issue, this recognition was achieved by the late 1990s. Even the farmers changed their attitude by viewing themselves more and more as the best protection of the environment instead of going after the highest crop yields at all costs. A change in government after the 1999 elections that was triggered by an agri-environmental scandal (dioxins in chicken) made it possible to start with a soil erosion control policy as is illustrated by the 2001 subsidy decree of the Flemish government. It can be concluded that the successful interaction between policy makers, farmers and scientists was critical to the emergence of this soil conservation policy (Fig. 4). Such an integration between policy makers and stakeholders in a collaborative way is emerging now and is a big step away from the autocratic top–down approach that used to be the case (e.g. Mullner et al., 2001). The role of science within this new policy is in accordance to what Cortner (2000) puts forward: a holistic and integrated science together with public involvement is required to achieve long-term ecological sustainability.

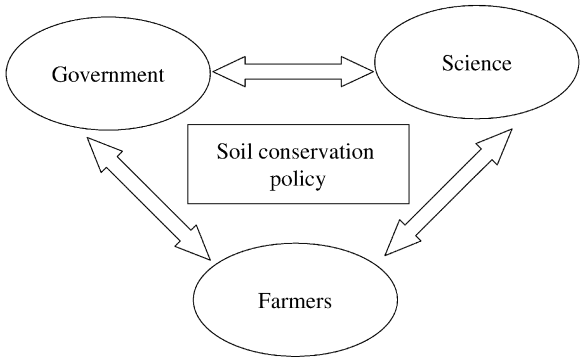

Fig. 4. Diagram illustrating the framework for a successful soil conservation policy in Flanders through the interaction of policy makers, scientists and farmers.

The new decree and the soil conservation policy, however, urges the development of soil erosion control management plans and the implementation of control measures as soon as possible. Such a rapid development (less than 10 years between recognition and actions taken in the fields) poses a serious threat to the viability of the control policy. Indeed, the whole organisation of the policy is at present not ideal and farmers are overwhelmed with information. Furthermore, the policy does not have a clear goal, which makes it difficult to select the optimal set of control measures. Further investigation on the applicability of several control measures for the situation in Flanders remains necessary in order to convince farmers to implement them.

The conclusions that could be drawn for the situation in Flanders are most probably also valid for other regions and countries, including the European Union. A successful soil conservation policy can only work out if all involved parties (farmers and/or land owners, local and regional authorities, scientists and the general public) are co-operating, not only in its implementation when measures are taken in the field, but right from the first phase of recognition through policy decision making and planning. This needs a lot of time and resource investment and it may certainly take considerable time before significant results are coming out.

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